S103 Discovering science

Assessment Booklet 3 (February 2007 presentation)

The Open University

Contents

IMPORTANT INFORMATION ABOUT TMAs 06–09

You should select THREE TMAs from TMAs 06, 07, 08 and 09. If you submit all four, the last one you submit will be returned to you unmarked. TMAs 07, 08 and 09 are in this Assessment Booklet. TMA 06 was in *Assessment Booklet 2*. We STRONGLY recommend that you submit TMA 06 as one of your three choices. The material that it assesses underpins, to a greater or lesser extent, concepts that you will need to rely on at higher levels of study.

This Assessment Booklet is for students who are studying the S103 2007 presentation, which began in February 2007.

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13.1

Knowledge and understanding

In the context of the topics covered in S103, you should be able to demonstrate knowledge and understanding of:

1 the terminology, nomenclature, classification systems, conventions and units used in biology, chemistry, Earth sciences and physics, appropriate to study at this level;

2 some of the underlying facts, concepts, principles and theories associated with the study of science;

3 methods of acquiring, interpreting and analysing scientific information;

4 the processes that shape the natural world at different time-scales and scales of size;

5 the benefits of a multidisciplinary and interdisciplinary approach in advancing scientific knowledge and understanding;

6 the contribution of science to informed debate about some aspects of environmental and social issues.

Cognitive skills

On completion of S103, you should also be able to:

1 make sense of information presented in a variety of ways, including text, tables, graphs, diagrams and figures, numerical and mathematical descriptions, and computer-based multimedia;

2 understand and make use of the facts, concepts, principles and theories relating to the main subject areas in science;

3 apply your knowledge and understanding of scientific concepts to address familiar and unfamiliar problems;

4 describe, analyse and interpret scientific information and data;

5 make links/connections and recognize associations/relationships among different subject areas;

6 understand the use of simple analogies and models in order to explain scientific concepts;

7 classify an appropriate range of organisms, objects and/or systems on the basis of similarities and differences.

Key skills

On completion of S103, you should also be able to:

1 communicate scientific topics clearly and concisely, using methods appropriate to your purpose and audience;

2 use mathematical skills appropriate to the study of science at this level;

3 solve numerical problems using non-computer based methods;

4 process, interpret and present data using appropriate qualitative and quantitative techniques;

5 plan and implement efficiently, effective ways of working, so demonstrating time-management and organizational skills;

6 reflect on the experience of learning in order to develop more effective learning strategies.

Practical and/or professional skills

On completion of S103, you should also be able to:

1 handle materials safely by complying with safety instructions and being aware of any specific hazards associated with the use of the materials;

2 make and record appropriately, observations and measurements of a quantitative and qualitative nature;

3 consider issues of accuracy, precision and uncertainty in the recording and analysing of data;

4 interpret data derived from laboratory and field observations and measurements in terms of the appropriate underlying scientific theories.

Tutor Marked Assignment S103 07

Covering: Block 9

Cut-off date: Tuesday 7 August 2007

Completing your TMA

Use A4-sized paper for your assignment, and leave a wide margin for your tutor's comments. Put your name, personal identifier, the course code and the assignment number at the top of *every* sheet.

Sending in your TMA

You must attach the TMA form (PT3), enclosed with the course materials, to your assignment when you send it to your tutor. You should complete Section 1 of the form, taking particular care to enter correctly your personal identifier, the course code and the TMA number, as described in 'Submitting TMAs' in the *Assessment Handbook*. Before mailing, make sure that you have put your name and address on the envelope. Do *not* send the TMA to your tutor using recorded or guaranteed delivery. *Do* make sure that you obtain a proof of posting certificate and, if possible, that you have kept a copy of your TMA.

Introduction

You are expected to complete three TMAs from a choice of TMA 06, TMA 07, TMA 08 and TMA 09. You are *strongly* recommended to choose TMA 07 (and to study all of Block 9) if you are planning to take courses allied to the biological sciences or health studies at Level 2 or Level 3. Some aspects of Block 9 also complement higher-level study of chemistry and Earth sciences.

This assignment consists of five questions relating to Block 9. We recommend that you read through all the questions before you begin to study the Block and its associated DVD-ROM material.

You must submit all your answers to the TMA at the same time, along with a PT3 form.

Each of the questions indicates:

- the block objectives tested (listed in the *Study File for Block 9*)
- the S103 learning outcomes that the questions will help you to achieve (listed on pages 2–3 of this booklet)
- the percentage of marks for this TMA allocated to that question.

You should bear in mind the detailed advice on how to tackle the S103 assignments previously given in *Assessment Booklet 1*; you may wish to read that advice again before beginning this assignment. *You may be penalized for not paying attention to this advice, particularly in relation to planning an answer, the use of diagrams, and how to reference your account*. You should also be sure to take account of any advice your tutor has given you on previous TMAs.

Question 1

This question relates mainly to Objective 18 of Block 9, and carries 20% of the marks available for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1 and 2

Cognitive skills: outcomes 1, 2 and 6

Key skills: outcome 1

We recommend that you complete Block 9 Activity 8.4 before you answer this question.

This question focuses on the two different types of nuclear division, mitosis and meiosis. Consider an animal cell with a diploid number of six chromosomes.

(a) (*4 marks*) *Draw* a fully labelled diagram of this cell at metaphase of mitosis.

(b) (*4 marks*) *Draw* a fully labelled diagram of this cell at metaphase I of meiosis.

(c) (i) (*4 marks*) *Describe* the fundamental difference between the positions of the chromosomes in your two diagrams. (*Two or three sentences.*)

(ii) (*8 marks*) *Explain, in no more than 150 words*, the significance of the different positions of the chromosomes at these stages of mitosis and meiosis and what this means for the type of progeny cells that result.

Question 2

This question relates mainly to Objectives 1, 8 and 14 of Block 9, and carries 15% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1 and 2

Cognitive skills: outcome 2

Key skills: outcome 1

We recommend that you complete Block 9 Activity 7.1 before you answer this question.

(a) (*2 marks*) In living organisms there is a constant balance between energy-requiring and energy-releasing activities. *State one specific example* of an energy-requiring process and *one specific example* of an energy-releasing process. (*A sentence for each.*)

(b) (*3 marks*) *Describe* the role of ATP in energy transfer. (*A few sentences.*)

(c) (*10 marks*) The biosynthetic process of photosynthesis consists of two distinct stages, the light reactions and the dark reactions. ATP and NADP.2H, which are manufactured in the light reactions, are then used to 'drive' the dark reactions. *Explain briefly* (using around 100 words for each answer)

(i) how ATP is produced by the light reactions of photosynthesis

(ii) how carbon dioxide is converted into 3C sugar phosphate in the chloroplast and then ultimately into sucrose in the cytosol.

Question 3

This question relates mainly to Objectives 34 and 35 of Block 9, and carries 10% of the marks for this assignment. It will also help with your achievement of the following learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 2 and 3

Cognitive skills: outcomes 1 and 4

Key skills: outcomes 1 and 2

Practical and/or professional skills: outcome 4

A student was picking up fallen holly leaves in July when she was asked by a neighbour to explain the appearance of the holly leaves in his garden. She immediately noticed that Bush A, in the front garden overlooking a busy road, had many leaves with discoloured 'blisters' whereas Bush B, in the rear garden, formed part of a hedge with the local park and had fewer of these blisters but a large number of leaves with V-shaped cuts.

She realized that the blisters were a result of the activity of holly leaf miners and planned to collect at random 40 leaves from each bush, and to analyse them to quantify and compare the causes of death (mortality factors) of the holly leaf miner.

Table 1 Mortality factors among holly leaf miners.

Mortality factors	**Bush A / number observed**	**Bush B / number observed**
Larva died for unidentified reason D_2	6	1
Larva killed by parasitic wasp D_3	4	2
Larva or pupa eaten by bird D_4	3	17
Pupa killed by parasitic wasp D_5	4	6
Pupa died for unidentified reason D_6	18	8
Adult emerged successfully N_6	5	6
Total number of leaves investigated	**40**	**40**

(a) (*3 marks*) Carefully follow the holly leaf miner programme on the DVD ('Part 2 – calculating k values'), inserting the numbers for Bush A from the Table 1 above. Record the calculated values of k_4, k_5 and k_6.

(b) (*1 mark*) Repeat the process for Bush B, also recording the values of k_4, k_5 and k_6.

(c) (*2 marks*) What do these k values tell you about the similarities and differences in the causes of death of the holly leaf miners in the two different bushes investigated?

(d) (*1 mark*) *Suggest* one reason that could account for a difference.

(e) (*3 marks*) *List* three practical tips that you would offer to future students for increasing the quality of data generated in their investigation of mortality factors of holly leaf miners on a local holly bush.

Question 4

This question relates mainly to Objectives 1, 16 and 22–24 of Block 9, and carries 20% of the marks for this assignment. It will also help with your achievement of the following learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1 and 6

Cognitive skills: outcomes 2 and 3

Key skills: outcomes 1 and 3

Cystic fibrosis (CF) is a disease that affects the lungs as well as the pancreas and sweat glands. It is a hereditary disease most common in white children: a survey of families in the United States showed its incidence to be 1 in 2000 white births, 1 in 17 000 African-American births and 1 in 100 000 Asian births. Today sufferers often live to adulthood and reproduce.

(a) Inheritance of the condition is *autosomal* and the *recessive* gene is found on chromosome 7. Individuals who are *heterozygotes* are known as carriers and do not show the condition.

(i) (*3 marks*) What are the meanings of the three words in italics in part (a) above?

(ii) (*7 marks*) Decide on a suitable letter to represent the gene symbols and *draw* a mating diagram (along the lines of either Figure 8.8 or 8.9 of Block 9) to show the cross between two carriers. *State* the phenotypic ratio and the genotypic ratio of the offspring in the F_1 generation.

(iii) (*2 marks*) Show the mating diagram and state the phenotypic proportions you would expect in the offspring of another cross between a CF carrier and a CF sufferer.

(b) Several types of mutation can cause CF. About 70% of patients show the type of mutation known as a deletion in one part of a large gene on chromosome 7. The normal DNA nucleotide sequence (reading from left to right) of a small part of this gene is as follows:

Position	1	2	3	4	5	6	7	8	9						
Nucleotide	**T**	**A**	**G**	**T**	**A**	**G**	**A**	**A**	**G**	**C**	**C**	**A**	**C**	**A**	**A**

(i) (*3 marks*) *Write down* the equivalent sequence for mRNA and hence work out the sequence of amino acids coded in the polypeptide produced. (You can use the usual abbreviations for the names of the amino acids.)

(ii) (*5 marks*) The CF deletion is of three nucleotides (numbers 6, 7 and 8) from the sequence shown above. Work out what would be the new amino acid sequence in the polypeptide now produced following the CF mutation. Suggest how this could change the function of the protein produced by the gene and could cause CF.

Question 5

This question relates mainly to Objectives 3, 4, 6 and 37 Block 9, and carries 35% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1 and 2

Cognitive skills: outcomes 2 and 6

Key skills: outcome 1

Write a short account of *no more than 500 words* in which you discuss:

- the general structure of enzyme proteins, and
- how the structure of enzymes allows them to fulfil their biological role.

To ensure good coverage of these topics you should make sure you include the following terms in your account:

amino acids, primary structure, peptide bonds, weak bonds, higher-order structure, globular protein, specificity, energy barrier, active site, enzyme-substrate complex, catalyst.

Before preparing your answer to this question you should read the Appendix to the *Study File for Block 2*, which explains how you should reference your source materials. You are expected to reference *in full* the sources that you use to prepare your answer, with references embedded in the text and linked to a reference list at the end of your account. This will give you practice in the correct use of references – something you will be expected to do in the end-of-course assessment (ECA). Marks for referencing are included within the communication skills allocation (see Mark allocation opposite for details).

N.B. (Multiple references to the same source): This is a reminder that *Stop Press 3* explained how you could make multiple reference to a single source.

You can use either the numbered-referenced system, or the 'Bradshaw et al., 1998' type of system, with an individual reference to each citation in the reference list.

Alternatively, you can cite the first reference made to the text with full details in the reference list, and then subsequently use a shortened version in the reference list including the term 'op. cit.' (meaning work already cited) and the page number the reference relates to. (For example: Bradshaw et al., op. cit., p. 70.)

Advice on answering this question

This question is designed to provide you with practice in selecting relevant information from more than one source and compiling this material to write a long account. This is a skill you will need for the ECA. You are strongly advised to read *The Sciences Good Study Guide* (SGSG) Chapter 9, Sections 5.2, 5.3 and 5.4, which give guidance on how to approach this sort of work, and to complete Activity 13.4 in Block 9 before tackling this question. (You will also find it useful to have studied DVD-multimedia Activity 7.1,'Cells and Energy', in Block 9.)

Communication skills

You can assume that you are writing for an audience of S103 students who have studied up to and including Block 8 of the course. You may therefore use terms from this block and from earlier blocks of the course without defining them.

As with the account you wrote in TMA 02 it is important that you plan your account before you attempt your first draft. A good way to start is to make notes from relevant course materials and then use these notes to compose your draft account. You may wish to review your answer to the TMA 02 question, together with the advice given by your tutor, before you start this question.

At the start of your answer you must include an introduction that is relevant to the discussion that follows in the main body of the account, and at the end you must include a conclusion that is relevant to the preceding account and draws together the threads of your discussion. You should not use headings for each section.

It is important that you pay attention to the quality of your writing. The main topics should be presented in a logical order, and should be linked clearly to provide a coherent discussion. The points should be made clearly, with no ambiguities of expression and with correct vocabulary, punctuation and sentence construction; the account should be written at the correct level for your audience.

You should write concisely, avoiding the inclusion of irrelevant or redundant material and ensuring that your account does not exceed 500 words. You *must* state the approximate number of words you have used at the end of your account. Your account should be divided appropriately into paragraphs, and spelling carefully checked. Finally you must reference *in full* the sources that you have used for your account, as noted at the start of this question, making sure you use the correct format; a reader should be able to pinpoint the sources you have used.

You can use diagrams to illustrate your account if you wish. Any diagrams must be given titles and be referred to in the text of your answer. They should be hand-drawn and, just like equations, they do *not* count towards the word limit. If figures from the course materials are used they should be adapted to suit the content of your account – *you must not copy diagrams directly from the course materials but rather customize them to make your points*. If you have difficulty producing hand-drawn diagrams because of a manual or visual impairment you should contact your tutor for advice.

Plagiarism

Remember that you *must not* simply copy or closely paraphrase blocks of text from the course materials or elsewhere, but write in your own words. If your tutor finds you have not used your own words sufficiently, you will have marks deducted from your score.

Mark allocation

- 20 marks for scientific content
- 15 marks for communication skills.

Tutor Marked Assignment S103 08

Covering: Block 10

Cut-off date: Tuesday 28 August 2007

Completing your TMA

Use A4-sized paper for your assignment, and leave a wide margin for your tutor's comments. Put your name, personal identifier, the course code and the assignment number at the top of *every* sheet.

Sending in your TMA

You must attach the TMA form (PT3), enclosed with the course materials, to your assignment when you send it to your tutor. You should complete Section 1 of the form, taking particular care to enter correctly your personal identifier, the course code and the TMA number, as described in 'Submitting TMAs' in the *Assessment Handbook*. Before mailing, make sure that you have put your name and address on the envelope. Do *not* send the TMA to your tutor using recorded or guaranteed delivery. *Do* make sure that you obtain a proof of posting certificate and, if possible, that you have kept a copy of your TMA.

Introduction

You are expected to complete three TMAs from a choice of TMA 06, TMA 07, TMA 08 and TMA 09. You are *strongly* recommended to choose TMA 08 (and to study all of Block 10) if you are planning to take courses allied to the Earth sciences or planetary sciences at Level 2 or Level 3.

This assignment consists of three questions relating to Block 10. We recommend that you read through all the questions before you begin to study the Block and its associated DVD-ROM material.

You must submit all your answers to the TMA at the same time, along with a PT3 form.

Each of the questions indicates:

- the block objectives tested (listed in the *Study File for Block 9*)
- the S103 learning outcomes that the questions will help you to achieve (listed on pages 2–3 of this booklet)
- the percentage of marks for this TMA allocated to that question.

You should bear in mind the detailed advice on how to tackle the S103 assignments previously given in *Assessment Booklet 1*; you may wish to read that advice again before beginning this assignment. *You may be penalized for not paying attention to this advice, particularly in relation to planning an answer, the use of diagrams, and how to reference your account*. You should also be sure to take account of any advice your tutor has given you on previous TMAs.

Question 1

This question relates mainly to Objectives 1, 10–12, 14–20, 27 and 30 of Block 10, and carries 48% of the marks available for this assignment. It will also help you with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1–4

Cognitive skills: outcomes 1–4

Key skills: outcomes 1–3

This question concerns the information we can find from rocks about the age and processes of geological episodes.

(a) (*14 marks*) Consider the following scenario. At the bottom of a muddy sea, sediment is buried, and a mudstone is eventually formed at temperature X and pressure Y. As the rock becomes buried deeper and deeper, it begins to change. At 250 °C and 2 kb (kilobar) pressure, the rock turns to slate. Further changes occur at 500 °C and 5 kb, and then again at 600 °C and 7 kb. Copy and complete Table 1 (below) by adding the details for the rock that is formed at 500 °C and 5 kb, and then the entry for the rock that is formed at 600 °C and 7 kb. There is no need to make the entries any longer or more detailed than those already given for the mudstone and slate.

Table 1 Changes in the composition of rock found at the bottom of a muddy sea over time.

Temperature / °C	Pressure / kilobar	Rock	Type	Main mineral present	Appearance
X	Y	Mudstone	Sedimentary	Clay minerals	Fine grained dark rock. May have distinct stratification
250	2	Slate	Low grade metamorphic	Mica	Fine grained and grey with some dark flecks
500	5				
600	7				

(b) (*4 marks*) *Briefly explain* why the minerals present and appearance of the four rocks in your completed table are different. (*Two or three sentences.*)

(c) (*6 marks*) In this question you will be drawing a section of a cliff that comprises three rock types, labelled A, B and C. Rock C corresponds to the last entry in your completed table (i.e. the rock that formed at 600 °C and 7 kb).

A geologist sees a cliff where rock C forms the lower half of a cliff, and is immediately overlain by a sandstone (rock B) comprising well-rounded grains with finely pitted, frosted surfaces. The sandstone reaches to the top of the cliff. In this cliff exposure, a gabbro (rock A) dyke passes right through both other rock types. Draw a section of this cliff showing the relationship between these three rocks types (A, B and C). Don't forget to label your section and to provide a key.

(d) (*4 marks*) Zircon crystals in a sample of rock C were analysed and found to have a daughter to parent (D/P) ratio of 1.8 for the decay scheme ^{235}U to ^{207}Pb. Estimate the age of rock C to two significant figures and comment *briefly* on the uncertainties and limitations on this estimate.

(e) (*10 marks*) Using the information from your completed table, the section of cliff mentioned in part (c) and your calculation in part (d), *write a short account* of the geological history of the area exposed in the cliff. Do not try to speculate, but concentrate on what you can actually tell from the evidence you have. (*No more than 200 words.*)

(f) (*10 marks*) Granite is an intrusive, felsic rock, which may be produced by partial melting or fractional crystallization. Explain how these processes can produce felsic magmas from more mafic parent magmas. (*No more than 200 words.*)

Question 2

This question relates mainly to Objective 15 of Block 3 and Objectives 6, 34, 39 and 41 of Block 10, and carries 12% of the marks available for this assignment. It will also help you with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1 and 3

Cognitive skills: outcome 2

Fossils can be used to provide evidence for continental drift or they can be used for biostratigraphy, but fossils from the same species cannot be used for both

(a) (*4 marks*) In two columns, list two of the most important attributes of species and their fossils that can provide evidence of continental drift, and two of the most important attributes of species and their fossils that can be used for biostratigraphy.

(b) (*8 marks*) Consider the two animals below, now found only as fossils.

(i) *Dactylioceras*: an ammonite found in marine Jurassic rocks between 180–190 Ma worldwide.

(ii) *Cynognathus*: a large land based carnivorous reptile found in the Permian and Triassic rocks of South America and South Africa.

State which of these species would be suitable for providing evidence of continental drift and which for biostratigraphy. Explain why each species would be suitable for the purpose you have stated and why it is not suitable for the other.

Question 3

This question concerns the relationship between climate and the Earth's systems. It relates mainly to Objectives 22, 23, 31, 39, 40, 41 and 43 of Block 10 although material from Block 2, 3 and 4 is also relevant, and carries 40% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1 and 4–6

Cognitive skills: outcomes 1–5 and 7

Key skills: outcome 1

The Earth is a dynamic planet where there are many complex interactions between the different Earth systems.

Write an account of *about 700 words* (up to 800 is acceptable, but you must not go over this limit) that speculates what might happen to the four Earth systems if the heat loss from inside the Earth reduced by half.

Before preparing your answer to this question you should read the Appendix to the *Study File for Block 2*, which explains how you should reference your source materials. You are expected to reference *in full* the sources that you use to prepare your answer, with references embedded in the text and linked to a reference list at the end of your account. This will give you practice in the correct use of references – something you will be expected to do in the end-of-course assessment (ECA). Marks for referencing are included within the communication skills allocation (see Mark allocation opposite for details).

N.B. (Multiple references to the same source) This is a reminder that *Stop Press 3* explained how you could make multiple reference to a single source.

You can use either the numbered-referenced system, or the 'Bradshaw et al., 1998' type of system, with an individual reference to each citation in the reference list.

Alternatively, you can cite the first reference made to the text with full details in the reference list, and then subsequently use a shortened version in the reference list including the term 'op. cit.' (meaning work already cited) and the page number the reference relates to. (For example: Bradshaw et al., op. cit., p. 70.)

Advice on answering this question

This question is designed to provide you with practice in selecting relevant information from more than one source and compiling this material to write a long account. This is a skill you will need for the ECA. You are strongly advised to read *The Science Good Study Guide* (SGSG) Chapter 9, Sections 5.2, 5.3 and 5.4, which give guidance on how to approach this sort of work, to complete Activity 10.4 in the *Study File for Block 10* and/or Activity 13.4 in Block 9, and to re-read relevant sections of Block 4 before tackling this question.

Science content

Your account will need to explain (not necessarily in this order)

- what the four Earth systems are (briefly)
- how the systems interact with each other
- what might happen to each system in this scenario
- how likely this scenario is.

Communication skills

You can assume that you are writing for an audience of S103 students who have studied up to and including Block 9 of the course. You may therefore use terms from this block and from earlier blocks of the course without defining them.

As with the account you wrote in TMA 02 it is important that you plan your account before you attempt your first draft. A good way to start is to make notes from relevant course materials and then use these notes to compose your draft account. You may wish to review your answer to the TMA 02 question, together with the advice given by your tutor, before you start this question.

At the start of your answer you must include an introduction that is relevant to the discussion that follows in the main body of the account, and at the end you must include a conclusion that is relevant to the preceding account and draws together the threads of your discussion. You should not use headings for each section.

It is important that you pay attention to the quality of your writing. The main topics should be presented in a logical order, and should be linked clearly to provide a coherent discussion. The points should be made clearly, with no ambiguities of expression and with correct vocabulary, punctuation and sentence construction; the account should be written at the correct level for your audience.

You should write concisely, avoiding the inclusion of irrelevant or redundant material and ensuring that your account does not exceed 800 words. You *must* state the approximate number of words you have used at the end of your account. Your account should be divided appropriately into paragraphs and spelling carefully checked. Finally you must reference *in full* the sources that you have used for your account, as noted at the start of this question, making sure you use the correct format; a reader should be able to pinpoint the sources you have used.

You can use diagrams to illustrate your account if you wish. Any diagrams must be given titles and be referred to in the text of your answer. They should be hand-drawn and, just like equations, they do *not* count towards the word limit. If figures from the course materials are used they should be adapted to suit the content of your account – *you must not copy diagrams directly from the course materials but rather customize them to make your points.* If you have difficulty producing hand-drawn diagrams because of a manual or visual impairment you should contact your tutor for advice.

Plagiarism

Remember that you *must not* simply copy or closely paraphrase blocks of text from the course materials or elsewhere, but write in your own words. If your tutor finds you have not used your own words sufficiently, you will have marks deducted from your score.

Mark allocation

- 25 marks for scientific content
- 15 marks for communication skills.

Tutor Marked Assignment S103 09

Covering: Block 7, Parts 7–11, and Block 11

Cut-off date: Tuesday 11 September 2007

Completing your TMA

Use A4-sized paper for your assignment, and leave a wide margin for your tutor's comments. Put your name, personal identifier, the course code and the assignment number at the top of *every* sheet.

Sending in your TMA

You must attach the TMA form (PT3), enclosed with the course materials, to your assignment when you send it to your tutor. You should complete Section 1 of the form, taking particular care to enter correctly your personal identifier, the course code and the TMA number, as described in 'Submitting TMAs' in the *Assessment Handbook*. Before mailing, make sure that you have put your name and address on the envelope. Do *not* send the TMA to your tutor using recorded or guaranteed delivery. *Do* make sure that you obtain a proof of posting certificate and, if possible, that you have kept a copy of your TMA.

Introduction

You are expected to complete three TMAs from a choice of TMA 06, TMA 07, TMA 08 and TMA 09. You are *strongly* recommended to choose TMA 09 (and to study all of Blocks 7 and 11) if you are planning to take courses allied to the planetary sciences, physics or astronomy/cosmology at Level 2 or Level 3.

This assignment consists of five questions relating to Blocks 7 and 11. We recommend that you read through all the questions before you begin to study Block 11 and its associated DVD-ROM material.

You must submit all your answers to the TMA at the same time, along with a PT3 form.

Each of the questions indicates:

- the block objectives tested (listed in the *Study File for Block 9*)
- the S103 learning outcomes that the questions will help you to achieve (listed on pages 2–3 of this booklet)
- the percentage of marks for this TMA allocated to that question.

You should bear in mind the detailed advice on how to tackle the S103 assignments previously given in *Assessment Booklet 1*; you may wish to read that advice again before beginning this assignment. *You may be penalized for not paying attention to this advice, particularly in relation to planning an answer, the use of diagrams, and how to reference your account.* You should also be sure to take account of any advice your tutor has given you on previous TMAs.

Question 1

This question relates mainly to Objectives 1, 12, 14–17, 23–24, 26 and 30 of Block 7, and carries 20% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1–3

Cognitive skills: outcomes 1–4

Key skills: outcomes 1–3

(a) (*3 marks*) A light beam has a wavelength of 255 nm. In what part of the electromagnetic spectrum is this light to be found? *Calculate* the energy of the photons that make up this beam. Give your answer in electron volts (eV). Remember to show your working clearly.

(b) (*5 marks*) This light beam is directed upon a diffraction grating placed 1.0 m from a screen coated in a fluorescent material. The first order diffraction pattern spot observed on the screen is found to be 5.5 cm from the centre of the diffraction pattern. *Calculate* the number of lines per millimetre in the grating. Remember to show your working clearly.

(c) (*2 marks*) The same light beam is then directed onto a metallic surface. The minimum energy required to liberate photoelectrons from the surface is 4.5 eV. Do the incident photons have enough energy to liberate electrons from the metal surface and, if so, what happens to any residual energy of the photons?

(d) (*5 marks*) In part (b) light behaved as a wave but in part (c) light behaved as a particle.

(i) *Briefly discuss* whether there is any evidence that electrons can show wave-like properties. (*Two or three sentences.*)

(ii) In view of your answer to part (d) (i), *explain* if it is possible for a human body to show wavelike behaviour.

(e) (*5 marks*) *Discuss* how Einstein's suggestion that light may be treated as 'particles' or quanta of energy can explain the observations of the photoelectric effect. Your answer should be about 150 words.

Question 2

This question relates mainly to Objectives 3, 14, 18, 20 and 21 of Block 11, and carries 20% of the marks for this assignment. To gain full marks you must clearly show your working in any calculation and express your answers to an appropriate number of significant figures. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 2–4

Cognitive skills: outcomes 2–4

Key skills: outcomes 2 and 3

(a) (*7 marks*) The spectrum of a typical star may be approximated as that of a blackbody spectrum with absorption lines superimposed upon it.

In a couple of sentences

(i) *explain* the origin of this blackbody spectrum and of the absorption lines.

(ii) *explain* why the spectrum of a typical distant galaxy will look similar to the spectrum of a typical star, and also state in what way it will differ.

(b) (*13 marks*) The tenth brightest member of the cluster of galaxies known as 'Abell 1185' has a brightness of 2.70×10^{10} W m^{-2}. A line in its spectrum at a wavelength of 503.1 nm is identified as being a member of the Balmer series that has a rest wavelength of 486.1 nm. You may assume that the luminosity of the tenth brightest galaxy in any cluster is 1.00×10^{-41} W; the speed of light, c, is 3.00×10^5 km s^{-1}, and 1 Mpc = 3.09×10^{22} m.

(i) *Calculate* the distance to the Abell 1185 cluster of galaxies in metres, expressing your answer in scientific notation. Then convert this distance into megaparsecs.

(ii) *Calculate* the redshift of the tenth brightest galaxy in the Abell 1185 cluster.

(iii) *Calculate* its speed of recession in km s^{-1}, expressing your answer in scientific notation.

(iv) Use your answers to parts (i) and (iii) to *calculate* a value for the Hubble constant.

Question 3

This question relates mainly to Objectives 10, 12, 17, 18, 22, 24 and 28 of Block 11, and carries 37% of the marks for this assignment. To gain full marks you must clearly show your working in any calculation and express your answers to an appropriate number of significant figures. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1–4

Cognitive skills: outcomes 2–4

Key skills: outcomes 1–3

(a) (*10 marks*) The antimatter counterpart of an electron is a positron. You may assume that the mass of an electron, m_e, is 9.109×10^{-31} kg, the electric charge of an electron, $-e$, is -1.602×10^{-19} C, the speed of light, c, is 2.998×10^8 m s^{-1} and that 1 keV = 1.602×10^{-16} J.

(i) How do the mass and the electric charge of a positron compare with those of an electron?

(ii) *Calculate* how much energy is liberated (in joules) when a single electron and a single positron annihilate each other. Express your answer in scientific notation.

(iii) *Convert* this value in joules into an equivalent value in kiloelectronvolts.

(iv) In the light of your answer to (iii), *state* the mass of a positron in the unit keV/c^2.

(b) (*8 marks*) *In no more than 150 words, explain* how the early Universe came to contain almost, but not quite, equal numbers of electrons and positrons. Consider only events that occurred before the Universe was 10^{-5} seconds old and illustrate your answer with particle reactions as appropriate.

(c) (*10 marks*) In the early Universe, electrons and positrons were annihilated when the mean energy per particle in the Universe fell below the energy required to create an electron–positron pair.

(i) What were the mean energies per particle, and the age and temperature of the Universe when the electrons and positrons annihilated each other? *Explain* your reasoning.

(ii) What were the consequences of the electron–positron annihilation reactions for the subsequent contents of the Universe? (Your answer should pay particular attention to the *number* of electrons and positrons relative to other particles, and the overall *electric charge* of the Universe.)

(d) (*6 marks*) *Draw* a *Feymann diagram* showing the formation of a muon-antimuon pair from the collision of an electron and positron. Carefully label where annihilation and pair production may occur. *Draw* a second diagram to show the additional release of a high energy photon during muon/antimuon formation.

(e) (*3 marks*) What is meant by the term α_{em} (the 'fine structure constant')? *Explain* what α_{em} tells us about the relative probability of the formation of a three particle event (muon, antimuon and photon) compared with the formation of a muon and antimuon pair.

Question 4

This question relates mainly to Objectives 1 and 4 of Block 11, and carries 8% of the marks for this assignment. It will also contribute to your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1–4

Cognitive skills: outcomes 2 and 3

Key skills: outcome 1

The Sun is primarily composed of hydrogen and helium, with traces of the other elements. Its visible surface, the photosphere, is a dense and nearly opaque gas at a temperature of 6000 K. *Describe* the spectrum that originates at this surface due to the physical state of the material. *Explain* how the spectrum arises.

Above the photosphere is a much thinner atmosphere. *Describe* how this atmosphere modifies the spectrum as light passes through, explaining how the changes arise.

Completing all of the steps for this question should take no more than 200 words.

Question 5

This question relates mainly to Objectives 1, 4, 5, 23 and 24 of Block 11, and carries 15% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1–3

Cognitive skills: outcomes 1–3

Key skills: outcomes 1–3

(a) (*2 marks*) *Write* an equation showing the electric force between two positive electrical charges Q_1 and Q_2 separated by a distance r. Is this force attractive or repulsive?

(b) (*2 marks*) *Write* an equation showing the gravitational force between two masses m_1 and m_2 separated by a distance r. Is this force attractive or repulsive?

(c) (*5 marks*) Now *calculate* how many times stronger the electric force is than the gravitational force, between a proton of charge $+e$ and mass m_p at a distance r from an electron of charge $-e$ and mass m_e given that:

$e = 1.6 \times 10^{-19}$ C

$m_e = 9.1 \times 10^{-31}$ kg

$m_p = 1.67 \times 10^{-27}$ kg

$k_e = 9.0 \times 10^9$ N m^2 C^{-2}

$G = 6.7 \times 10^{-11}$ N m^2 kg^{-2}

Express your answer to the nearest order of magnitude.

(d) (*6 marks*) The electrical and gravitation forces are two of the four fundamental forces of nature. What are the other two forces? For each of these two forces, give an example of an interaction or process where the force may be considered to be important.